With the compliments of
John R. Freeman

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On Contemporary Technical Education

ADDRESS OF

JOHN R. FREEMAN

On behalf of the Engineering Societies at the

INAUGURATION OF

PRESIDENT CHARLES S. HOWE

Case School of Applied Science

CLEVELAND, OHIO, MAY 11, 1904

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ON CONTEMPORARY TECHNICAL EDUCATION.

ADDRESS OF JOHN R. FREEMAN*

ON BEHALF OF THE ENGINEERING SOCIETIES AT THE

INAUGURATION OF PRESIDENT CHARLES S. HOWE.

CASE SCHOOL OF APPLIED SCIENCE,

Cleveland, Ohio, May 11, 1904.

Mr. President:

As delegate on behalf of our Engineering Societies, I must explain that these also are Schools of Applied Science. They are the more attractive to students since they hold no examinations; all studies are elective and voluntary; one recites only when he feels like it; and the social element is pre-eminent.

Into this university of the Engineering Societies, we hope to receive all of your graduates and to retain them as fellow-students and warm friends to the end of their lives.

APPRECIATION OF THE TECHNICAL SCHOOL.

In speaking on behalf of the engineering profession, my first words must acknowledge our great debt to the technical school and that this debt is increasing from year to year. Our members are coming to be recruited in an ever-increasing proportion from the technical graduates ([1]).†

From the researches conducted in your laboratories, we obtain much of our most valuable engineering data.

Our best books of reference for the practicing engineer are nearly all prepared by the professors in these technical schools ([2]).

The strongest foundation for a country's future industrial and commercial welfare is to be found in Schools of Applied Science, well equipped, guided by men of broad mental horizon. This is scantily appreciated as yet by the mass of strenuous Americans, but

* Vice-President American Society of Mechanical Engineers; Member Board of Managers, Association of Engineering Societies.

In compliance with the invitation received, and, at the request of the Chairman, Mr. Freeman represented the Board at the inauguration of President Howe.

† Footnotes. See end of paper.

it has long been clearly seen by the Germans, and is beginning to be seen by the English (3).

The cost of duplicating the land, buildings, equipment and endowment of the largest and most complete technical school in the United States, training more than 1500 young men, is little more than half the cost of one of the latest battleships, and the running expenses of the largest technical school per year are about the same as for keeping a battleship in commission (4). The Technical School has a use no less important than the battleship in the "first line of national defense." The time has already come when the commonwealth and the nation should contribute more liberally to the burden of its support and help it to ever broader usefulness. With the increasing numbers of students and with the rapidly increasing cost of laboratory facilities needed for the best training, the need of funds is greater than private munificence can be relied upon to meet. The demonstration of their great value to the prosperity of the state is already complete (5).

In the re-awakening of the old spirit of commercial adventure in foreign lands, we must to-day base our hope of success on superior excellence and economy of manufacture and in the calling of our engineers to foreign lands.

The growth of our cities is laying a burden of new and larger problems on our departments of public works, a burden which only those trained in the Schools of Applied Science can carry wisely and well.

The business man, when he comes to see these matters clearly, will urge again and again a generous support to Schools of Applied Science by city, state and nation when private munificence falls short.

These schools need, as managers, the strongest men that can be found, the men of broadest horizon, the men that can arouse the noble ambitions of young men toward advancing the state of an art and that can impart the spirit of joy in work.

APPRECIATION OF THE TECHNICAL GRADUATE.

For twenty-five years I have been observing the increasing respect paid by our industrial leaders to the training gained in the technical school. The technical graduate himself has come to better understand his own limitations, and his need of a course outside, under instruction from the foreman and the mechanic. The man of business is coming to understand that there are "first," "seconds" the "thirds" produced, that some excel in judgment and some in skill, and that it is not the mere fact of being a technical graduate

that brings success, but that, given inborn executive ability, the training of college or technical school gives to its graduate a tremendous advantage over the man of equal native force who has not this training.

Twenty-eight years ago the finding of openings by my own fellow graduates was difficult and slow,—not a third of our men found openings of fair promise within the first six months; the average "captain of industry" did not then know just what a technical graduate was, or what he was good for.

We then listened to prophesies that the annual output of engineering graduates would soon overstock the market. To-day, notwithstanding that, during the past quarter of a century, technical schools have multiplied on every side and that classes in many of the older ones have increased fourfold, the output is quickly absorbed. The department head in one of our largest technical schools has told me repeatedly that in each recent year he has had applications from managers of important works for double the number of his graduates, and it is said that certain large and progressive concerns send an agent around the schools in January to select from the brightest of those who are to graduate in June.

The mere register of the occupation of the graduates from any leading School of Applied Science is a most eloquent commentary on the commanding influence of these schools.

Twenty-five years ago, among managers of works, I heard much about the good *practical* man and his superiority to the theoretical college graduate; to-day it is coming to be generally recognized that the *good* practical man is the one who has graduated from a technical school and who has then been seasoned by a few years of experience in bumping against corners of construction, and the technical graduate of proved business ability is in special demand.

The Technical School, the School of Mechanic Arts, and the Mechanics Correspondence School, each has its special and distinct value in our industrial life. We should make the technical school attractive to the brightest minds, and should look to it for our industrial and commercial leaders and for the best custodians of the public health, of our water supplies and other public works.

In order to get the most out of the existing technical schools, let us keep in mind the limitations within which they can do their most efficient work, and the fact that not every kind of work will be best done by a technical graduate. The students found without promise of final success should in all kindness be allowed to depart and not hold back the best.

Doubtless a man may give lines and grades as well, may drive an engine or detail steel work better, if his four years of early manhood have been spent gaining this dexterity and skill outside the technical school. The late Col. T. J. Borden, a sympathetic thoughtful man of 40 years' experience as manager of large industrial works, and himself a technical graduate, told me that for many years he had been observing that a faithful uneducated laborer would in general keep a more correct tally sheet of the unloading of a cargo than the bright high-school graduate whose thoughts were flying off to other things; that a large factory engine would be run with better attention and fewer breakdowns by a graduated stoker or oiler than by an expert machinist, who was liable to be scheming out improvements and to have his mind busy with something other than the mere operation of this machine; that often the best routine work was done by a man who was not capable of anything very much better.

The young man who is to follow a narrow routine through life will not have much added to his efficiency, as a machine, by the long elaborate course of the technical school. For those constitutionally deficient in ambition, or for those unfortunates who can never comprehend the art of getting on in the world, these four extra years are ill spent at school, but there are plenty of young men for whom this training of the technical school is the best possible training, and there is plenty of opportunity for a larger number of these men than all of our present schools can graduate.

Men cannot be shaped on the interchangeable system of the American Machine Shop, each will be a "special," and, as already remarked, there will be produced "firsts," "seconds," and "thirds," but fortunately the demand for all types and grades exceeds the possible supply for years to come.

Among the graduates, some will possess that rare faculty for which "initiative" is the phrase of the day, and among these there will be some who will possess that quality of balance and judgment, and attain such knowledge of men, that they will become great leaders, the captains, will establish their own industrial works or be called to the $10,000 positions which are always so hard to fill right. Others, without this business insight, but perhaps more learned and more skilful in engineering, will design machines and bridges, supervise factories, become the lieutenants and fill the $4000 and the $2000 positions, and a still larger number will do noble work as the sergeants, corporals and privates and be made better men by the broadening of their minds in their college course.

The training of no school can make the square peg fit easily in the round hole, and, out of a hundred boys, but few are born with the ear of a musician or the eye of an artist, or with the observing, inquiring, ingenious, imaginative mind, which schools can stimulate but cannot create, and without which conspicuous success in constructive engineering is impossible. But for the young man so fitted by nature, a technical school of broad scope and high aim is a royal road.

A ROYAL ROAD.

The old statement that "There is no royal road to learning" is untrue. The man of affairs has come to understand that *the technical school is a royal road to learning,* a shorter road, an easier road, through a more beautiful landscape, and in equal time attaining a broader outlook.

A man with the earnestness and persistence of John Brashier, the strong purpose of John C. Hoadley, the rugged common sense of Edwin Reynolds, the strong, kindly heart and quick intelligence of John Fritz, or the genius of Edison, may reach an equal height by a longer and more arduous road, and, like the athlete, increase his strength and harden his endurance in the greater effort; but the royal road of the technical school, in its four years, may, from its small group of a hundred, gathered part by chance and part by process of natural selection from more than ten thousand school boys, bring perhaps ten or twenty to the point that otherwise not more than one or two or three could hope to reach in twice these four years.

The technical school is not exclusively for the brilliant man. Much of the world's best work is done by the man of slow-moving intellect, to whom the good Lord has given the greater treasure of persistence, of steadfastness, with enough of imagination or instinct to feel what is concealed within the cloud on yonder difficult and distant hill.

There is danger in relying upon lectures and reading for teaching, and upon written examinations for measuring up a student and his fitness to continue on his four years' course. One of the greatest advantages of the technical school is found in its Laboratory method, for the reason that the personal, individual contact with the student daily in the laboratory gives an opportunity for helping the one who is slow to develop himself.

I have had perhaps twenty graduates tell me in familiar talk that the most helpful man to them of all the "Technology" professors was the lamented Holman. Why? First, because he was intellectually great and a noble man, and second, because he took

pains to get acquainted with them and their individual needs, *in the laboratory*. The ablest professors should be brought into earliest possible contact with the freshmen in the laboratory.

THE OPPORTUNITY FOR THE TECHNICAL GRADUATE.

A few moments ago we were considering the broader appreciation, by men of affairs, for the work of the technical school; let us for a moment review the causes of its great opportunity.

That the manufacture of power was the mainspring of the onward movement of the nineteenth century was made plain, perhaps more ludicidly than ever before, by that great engineer, whose recent loss we mourn, George H. Morison, in his Phi Beta Kappa address at Harvard in 1895.

In the skilful application of manufactured power lies the great opportunity of the engineer.

The distribution and use of manufactured power are increasing by leaps and bounds in a way that few of us can see in perspective.

It moves a thousand cotton spindles guided by a single hand, with the power of more than a thousand horses, ([6]) it draws your "20th Century Express;" large cotton factories in Montreal are driven by a waterfall nearly a hundred miles away; the power of Niagara rends the strongest chemical affinities. The chariot, as made in Cleveland, is horseless, but it is propelled by the power of 24 horses, all generated in a little space and derived from a harnessed explosion. In another part of your city, the most delicate and accurate engraving that the skill of the world has known, an astronomer's circle with markings correct within less than a second of arc, may go on in solitude as a result of a laborer shovelling coal under a steam boiler. To-day there is far more steam power used in Lowell than water power, and in your city of Cleveland the power manufactured from coal far exceeds that of the greatest single development of water power in the world ([7]), Niagara not excepted. The General Electric Co. had on its books, on Jan. 31, 1904, undelivered orders for steam turbines of an aggregate power of 350,000 horse power, an amount three times as great as the present total generation of power from Niagara and nearly half as great as the total water and steam power combined, in the six New England States, found by the census of 1880.

With the aid of unlimited power, work is performed in a larger way and with greater rush, and with this comes the greater need of executive ability, of captains and corporals of systematic, observing habit, equipped with the tools and training of the technical school.

This is a transition period, and never was there such opportunity for the trained engineer. Mechanical production must supply the natural increase due to the growth in population, and replace machines worn out by service, and even new machines by something newer. Here in Cleveland your horse cars were not worn out when the cable car replaced them, your cable railways were not worn out when the electric car came in. Not only the equipment, but the shop that makes it, must largely go into scrap.

Two or three years ago one of the leading engine builders of the world began on new shops in a city on the Great Lakes, the largest of their kind, designed for building engines of the most massive type. Hundreds of thousands of dollars were expended on these shops and their heavy machine tools, but, before these shops were occupied, customers were inquiring, not for engines but for steam turbines.

The leading pump builder of America began two years ago on new shops near New York, these also to be the largest in the world; the plans had been matured by years of study, for building pumping engines of the ordinary reciprocating type. Before these shops are ready for occupancy, the old and simple and inefficient type of centrifugal pump is suddenly so improved as to threaten a revolution which may profoundly change the type of shop equipment demanded.

A maker of valves and pipe fittings, a concern which had kept steadily up-to-date for more than a quarter of a century, started, about two years ago, to supply its expanding trade by a factory on the shores of Long Island Sound, designed to employ at first 2000 and later 4000 men. The plans were matured with rare care and judgment. First, their man of greatest skill in shop methods plans for his various machines and lays out his floor space. Next, the skilled mill engineer makes plans to house that floor space in. Next, an architect, of national reputation for his inborn sense of beautiful form and graceful line, models the outlines of exterior wall and windows and roof. Machine tools of latest design had been purchased, apparently everything had been provided for, when, just as the roofs are on, the successful demonstration of a new kind of tool steel, which permits of far deeper and more rapid cuts, calls a halt and requires a radical change.

All this is recent and the end is not in sight. Seventy-five years ago, when Cleveland was a frontier village, within the memory of a few men now living, the dry dock in the Boston Navy Yard was the most monumental piece of engineering construction and the greatest single work of internal improvement yet completed

within the United States, and the total of manufactured power in the United States did not equal the output of one of the large power stations of to-day.

It is only forty years since the first distinctive general School of Applied Sciences, or Institute of Technology, in this country, began, after years of patient explanation and pleading by that lovable, eloquent, prophetic, noble man of science, William Barton Rogers, and how profoundly it has influenced the whole course of higher education.

Not long ago I had a letter from a fine old gentleman of Boston who, educated in France, in his day and generation had been the best educated engineer in America and who began his practice on the earliest steam railroad, under the great Stephenson; one whose pleasure it had been through a life of uncommon length to follow engineering developments in varied lines. This man, who had seen the railroad born, the use of electricity and a thousand other marvelous results of scientific study, wrote of *the greater* opportunity of the young engineer of to-day!

Although the lines of work formerly recognized as engineering may be crowded, there are, on every side, unworked fields in which the trained engineer, possessing business ability, be he builder, sanitarian, chemist, machinist, or electrician, can introduce system, discover causes, lessen cost and improve the product and find for himself a competency and joy in work.

A PLEA FOR BREADTH OF CULTURE IN THE SCHOOL.

The other speakers to-day are presidents of colleges, educators of wide experience and national reputation, and it savors of rashness for me, in their presence, to venture opinions upon the aims and methods of a technical school, but during my twenty-five years of taking on one or more technical graduates in almost every year, and trying, through them, to keep in touch with the schools, I have so often found what has seemed to me a misapprehension among students, friends and patrons of technical schools, that, to an audience of patrons, teachers and students, a few words, from the standpoint of a business man and practicing engineer, may have some interest.

Why do we not find the greatest prizes of the industrial works and of civic administration going *more* often to the technical graduate? Why does the commercial department pay better salaries than the engineering department? We have all seen plenty of examples to prove that technical training can be of itself an aid rather than a bar to commercial success.

Have our men got too narrow a training in the technical school?

Within the past week I have chanced to hear two heads of great concerns, each employing many scientific men, say in substance that the old academic education fits better for the position where one deals with men, or for the $10,000 position, while the technical school fits better for the position that deals with materials, or for the $4000 position, and I note that sons of my old classmates are being sent first to Harvard or Yale or Dartmouth for *four* years and then to "Technology" for a *two* years course in science.

Six years time, from 18 to 24, is more than the average young man can afford to spend at school. It brings him into the works too late. When we more fully appreciate that *education, rather than information,* is the true aim of the technical school, then a broad education and sufficient information can both be given in a four years' course.

Can we not give a better education to the great majority of our students and plant in them thirst for information, by doing fewer things more profoundly and putting more emphasis on the personal element?

Is not one great captain of science or industry, like Pasteur, Kelvin, Ericsson, Bessemer, Westinghouse, Brush, Hiram Mills or Alex. Brown and a hundred others, worth more to his country and his neighborhood than a roomful of the very necessary and useful sergeants and corporals of science and industry?

Cannot our school do the most good and best serve all, and best stimulate the ambition of all, by trying to fit men for the position of captain; and, if the man, skilled in the application of science, has also executive skill and such knowledge of men that he can negotiate, convince and arouse men, will not he have a wider opportunity to do good and to advance the state of the art and the public welfare; and shall we not, by addressing our teaching to the highest grade, thus produce more of the $10,000 men and at the same time better $4000 men?

In separating students into many courses, is there not danger of splitting things too fine? Have the schools not already gone too far in specializing for the undergraduate?

It is a matter of slight importance to the builder of machines or of water works whether he takes the course in mechanical engineering, civil engineering, or general physics, *if he is fortunate in his teacher.*

The chief function of the Technical School is not the filling of a man's memory with formulas and with knowledge of how every-

thing is made, but rather is the training in methods of thoughtful research, of teaching how to put the question and where and how to find the answer, of how to set traps for our own unconscious errors, how to save time by understanding just what degree of precision is necessary to the case in hand, how to measure with certainty the limits of the ever-present error, and above all to develop and strengthen a warm, enthusiastic, undeviating love for the truth.

In my own college days, I did not have it made plain, and I failed to grasp the fact, that perhaps the greatest opportunity of college life is that of coming to better know one's fellow-men, and it is in failure to appreciate this, more than in any other one feature, that the professional school has failed in comparison with the older colleges. In the protest against the old education, exemplified in the early development of the Massachusetts Institute of Technology and other similar schools, the pendulum swung beyond the center, and the value of the social idea was for a time not appreciated. To many of us there was lost the inspiration and broadening, the deeper understanding of humanity that may come from entering into the daily life of the ancient civilizations enough to understand that human nature is much the same through three thousand years. We missed that focussing and sharpening of the wits which comes from taking time for the discussion of current events with our fellows.

We had a professor who wisely read to his class those verses on The Deacon's Masterpiece, "that was built in such a logical way," as typifying the ideal machine. McAndrews' Hymn may teach a deeper lesson. The man should be led to find inspiration in his machinery, while in the technical school.

A few weeks ago, in Chicago, I sat beside a classmate, a former "grind," now a successful man of business, at a gathering of the graduates of one of our largest technical schools. Said he, "We were brought up wrong in being taught to spend so much time on our studies; we practiced a false economy in being too thrifty in our earlier years." We were too late in learning that opportunity, sustaining power and a stimulus toward success, came more from a wise good-fellowship than from high scholarship, and that the art of being what in your terse Western phrase is called "a good mixer" was an art well worth time, money and paternal advice to cultivate. It is by giving the technical graduate a wise start in this direction that he will ultimately come more often into the larger opportunity and the higher salary of the commercial end.

This social feature is, in the final analysis, the chief value of the engineering societies. Although papers are presented in which one engineer so presents his experience that a hundred others may find each his own course more clear in attacking a similar problem, although one may hear presented in an evening hour the results of experiments and research that have cost a year of toil, all so summed up in a few lines of formulas or constants, that a repetition of this labor and expense is saved to all who follow, and although the master mind may publish in the transactions a study upon difficult and disputed points that will lighten labor or save mistakes to many of his fellows; yet, after all, the pre-eminent usefulness of the Society of Engineers is in the bringing of men into personal relation, inspiring the young man by personal contact with the man who has done things, giving the older men a chance to size up the growing young men; and, among equals, it removes the bitterness to personally know our successful competitor and to know that he is a good, honest man.

If it be asked what suggestions can be offered to his friend, the teacher, by a practicing engineer, who has for twenty-five years enjoyed taking "green graduates" and trying to help them on their post-graduate course, I venture the following:

Dwell on the principles of research, fill the student mind with a comprehension that the school is not so much for filling his memory with information as for teaching the scientific method.

Give more attention to the principles of writing reports in clear, exact and vigorous English, to measuring the exact meaning into every sentence. Teach what may be called "commercial rhetoric," bringing the result quickly into the view of the busy man and seeking to so arouse his interest in the opening paragraphs that he will continue reading instead of laying it aside for the leisure hours that may never come.

Emphasize the need, in the practical world, of "getting there" on time.

Recognize that a judicious "cramming for examination" is legitimate, and that how to do it with the least internal friction is a most worthy subject of instruction. In closing business contracts and in expert work, it is a much practiced and most useful art.

Direct attention to the conditions necessary for obtaining a maximum output from the human machine. How seldom a man gives, to his own body, the same care he would give to that of a $1000 horse! Long hours under stress in emergency are easy if the man knows how to avoid fatigue through variety, and has the will power to practice what he knows.

Probably there is no better way to save time and cultivate judgment than by practice in quick estimates between limits. What does that stone weigh? Not more than 6 tons, not less than 4. What will that casting cost? Not less than $50, not more than $100. If the owner asks the cost of repairing the tangled smash-up of ten minutes ago, the young engineer can give him almost instantly an estimate that may serve his purpose, and be correct, if he states it between limits, as, "not more than $10,000, and not less than $1000." Twenty-four hours later, he may be able to state it as not more than $5000, and not less than $4000.

Urge upon your colleagues the fact that they owe it, to their fellow-citizens and to the loyal intelligent public that supports the school, to promptly and continually translate the story of the latest discovery of abstruse science down to the understanding of the well-educated non-technical man.

Stimulate the interest of the students by continually bringing before them the results of the latest research and of what is being found out in other departments of the school.

Recognize the fact that these four years' time, with their attendant expense, are too valuable to be devoted to the attainment of mere manual dexterity. This can be more cheaply learned in the field or workshop than in the school. Do not shrink from turning out graduates who will be strong on theory, while perhaps weak on practice. They can get their practice outside after graduation, and perhaps under the quickening influence of some shortlived ridicule by the routine workman. The sound foundation of mathematics, the facility in handling and transforming difficult equations, the mental grasp of difficult considerations, so as to state them in the language of mathematics and quantity, must be acquired in the Technical School or the chances are they will never be acquired.

Finally, to the many students here, I can bring back no better word, from out the years since I left similar pleasant places, than to remind you how largely the success of a school depends on atmosphere and that every man has a share in forming public opinion; and to urge you to fill the atmosphere of the student of engineering with the fraternal spirit and with ideality,—ideality, with the love of thoroughness and with reverence for character.

NOTES.

(1) Out of the latest 1000 condidates for admission to the American Society of Civil Engineers in the three grades, member, associate member and junior, about 75 per cent. have graduated from a technical school; in the American Society of Mechanical Engineers, this proportion is 60 per cent.; in the Electrical Engineers, 44 per cent. In each society the proportion is largest among the junior members.

(2) Out of a catalogue of 55 technical books brought out by a leading American publisher of engineering books during the past year, 75 per cent. of the whole were by professors, mainly in Technical schools.

(3) See Presidential address of Sir Norman Lockyer, President of the British Association for the Advancement of Science, in September last, entitled "The Influence of Brain Power in History," devoted to urging the British Nation to come to the support of its Technical Schools.

(4) COST OF A BATTLESHIP.

The approximate cost of the hull of a first-class battleship is....	$3,250,000
The engines, machinery and engineering stores cost about......	1,300,000
For the largest ships the cost of armor is about................	1,750,000
For the largest ships the cost of armament is about............	1,050,000
The supplies and general equipment about......................	100,000
Total cost of a first-class battleship about...............	$7,450,000
For a ship of the Vermont class of 16,000 tons displacement, with the latest armament and including designs and superintendence, the total cost may approximate............................	$8,000,000

The cost of maintaining such a ship in commission will be nearly 50 per cent. more than for the three ships as stated below, which are of 12,000 tons.

The report of the Secretary of the Navy shows that the cost of maintaining the three battleships, Alabama, Kearsarge and Wisconsin, in commission for the year ending June 30, 1902, averaged	$441,248
Current repairs	30,914
Total	$472,162
The foregoing includes pay of officers, crew and marines, and cost of stores, including coal, but includes no allowance for depreciation. If depreciation be figured at the moderate rate of 5 per cent. annually, having regard to wear, and to improvements rendering much obsolete, this adds per year nearly....	400,000
	$872,162

COST OF A TECHNICAL SCHOOL.

Several of the leading schools of applied science are parts of great universities in which the accounts of different departments are so merged that it is difficult to separate the cost of plant and running expenses required for the courses in applied science.

The Massachusetts Institute of Technology is perhaps the most convenient example for present purposes, because of being almost exclusively a technical school. Its present site is on land of exceptionally high value for

business purposes, because of surrounding developments; therefore, I will not include the full sum for which this land could probably be sold.

It is estimated that a suitable site could be procured for........	$250,000
The estimated cost of replacing present buildings at present prices is	1,044,000
The total value of apparatus and furnishings, as estimated for insurance purposes, is	386,000
Approximate cost of duplicating plant........	$1,680,000
The endowment or stock, bonds and real estate producing direct income is about	1,150,000
Total	$2,830,000

The number of students last year was 1528.

The annual expenditure last year in round numbers was as follows:

Salaries	$320,000
Fuel	25,000
Water, gas and electricity	7,600
Repairs	16,000
Printing lecture notes, catalogues, etc........	14,000
Laboratory supplies and libraries	50,000
General supplies and maintenance	30,000
Miscellaneous	13,000
Total	$475,000

This amounts to an actual expenditure of about........ per student (including special students, some of whom take few studies and pay less than full fee). Reckoning the interest at 4 per cent. and depreciation on whole plant, buildings and furnishings, at 5 per cent. per annum, this adds about..	$311 91
making the total yearly cost per student........ of which he now pays a tuition of $250 and until very recently only $200.	$402

(5) The generous support given by Michigan, Wisconsin, and California to their great State Universities, which are coming to be in large proportion schools of applied science, may indicate a better appreciation of this service to the State than is yet found in the legislatures of our Eastern commonwealths, or than is yet disseminated through the mass of their intelligent citizens.

In 1903, Michigan paid from the State Treasury for the support of the State University	$559,835.03
The State raises by general taxation in the average year for the support of the State University	394,625
and in addition makes special appropriations or draws from accumulated funds.	
Wisconsin raised by direct taxation for the support of its State University	289,000
and when the regular annual appropriation is found insufficient the Legislature makes special appropriation. The entire disbursements on account of the State University last year amounted to	771,053

The University of California has an income for current expenses for 1904-05 of.. 659,808.96

mostly raised by direct taxation on property, of which sum nearly ⅓ is appropriated for departments in which engineering students predominate.

The Case School of Applied Science is not assisted from general taxation, but depends for support only on the income from its endowment and fees of students.

(6) A locomotive engine of the type used in drawing the 20th Century over the New York Central portion of the route has, under test, shown a continuous development of upward of 1200 horse power, at speeds of from 40 to 57 miles per hour.

From a large type of locomotive, recently put in service on the New York Central and Hudson River Railroad, an indicated horse power of approximately 2000 has been obtained.

On the Lake Shore road, indicator cards, taken from fast passenger trains at one minute intervals for an entire trip where the speed over an entire division averaged about the same as for the 20th Century Express, namely, 54 miles an hour, showed an average of about 1000 horse power for the entire division. For distances of 5 to 10 miles, powers as high as 1500 to 1600 horse power have been obtained.

	Horse Power.
(7) The total amount of water power now in use daily by the works located at Niagara is not far from....................	75,000
In addition to this, there are now generated at Niagara, and transmitted to Buffalo and other points, not far from..............	25,000
The aggregate capacity of the generators installed up to date at Niagara is about...........	130,000
On the American side an additional capacity is being provided of perhaps	50,000
And on the Canadian site the contracts have been let for machines capable of generating about	80,000
In the city of Cleveland an approximate estimate, reasonably made up by Mr. Ambrose Swasey and Mr. Scovill, vice-president of the Cleveland Electric Illuminating Co., puts it at...........	50,000
for the total of the large electric power and electric railroad plants.	
At the 73 large factories in Cleveland, they estimate the power used as	85,000
In small factories, lumber yards, office buildings, etc., etc., probably	25,000
Total present use of steam power in Cleveland............	160,000